Art,
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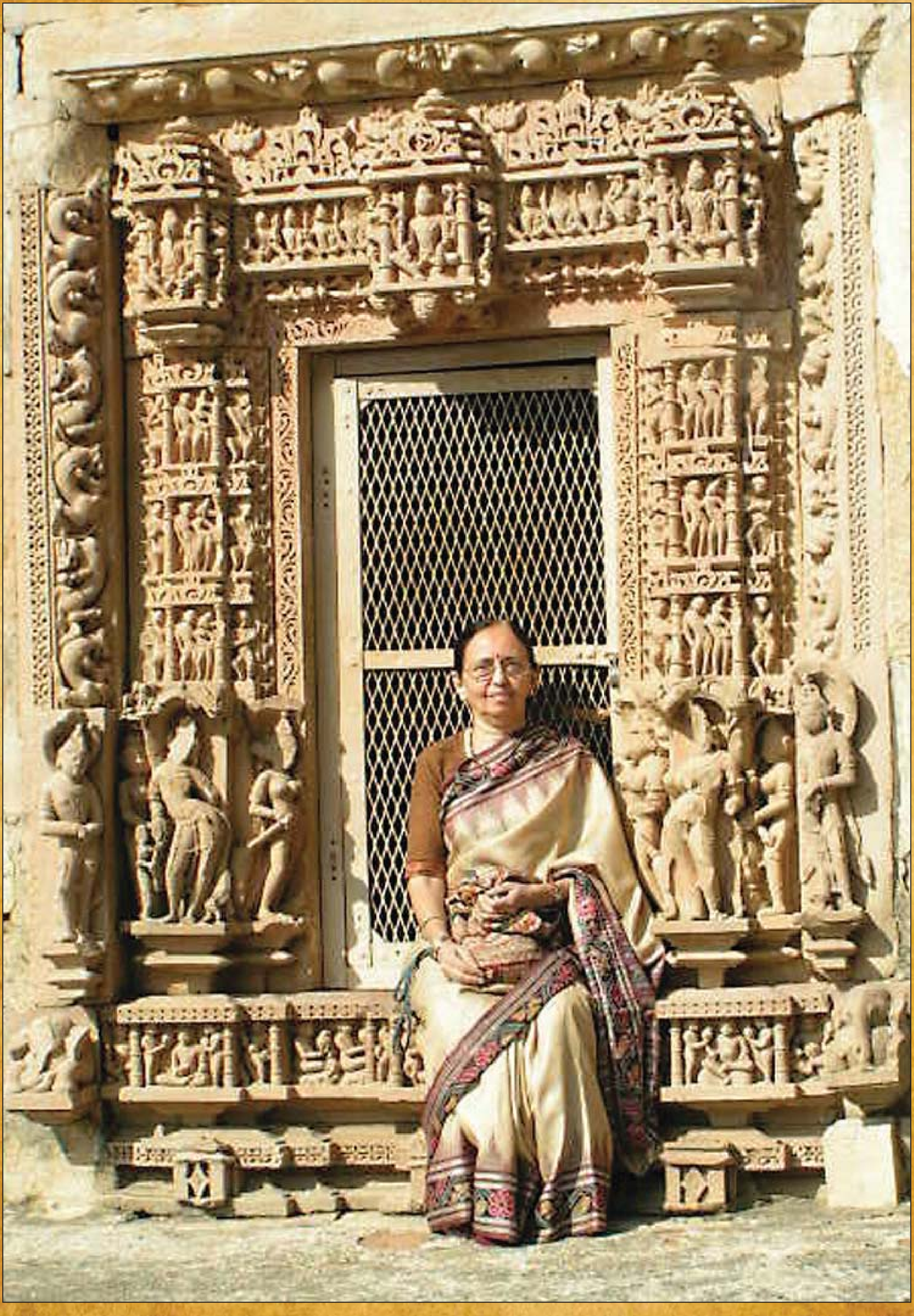
in South Asia



Dr. Devangana Desai at Khajuraho.

Art, Icon and Architecture in South Asia

Essays in Honour of Dr. Devangana Desai

Edited by

Anila Verghese | Anna L. Dallapiccola

VOLUME I

Aryan Books International
New Delhi

ART, ICON AND ARCHITECTURE IN SOUTH ASIA
Essays in Honour of Dr. Devangana Desai

ISBN: 978-81-7305-531-7 (Vol. I)
978-81-7305-533-1 (Set)

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First Published in **2015** by
Aryan Books International
Pooja Apartments, 4B, Ansari Road, New Delhi-110 002 (India)
Tel.: 23287589, 23255799; Fax: 91-11-23270385
E-mail: aryanbooks@gmail.com
www.aryanbooks.co.in

Designed and Printed in India by
ABI Prints & Publishing Co., New Delhi

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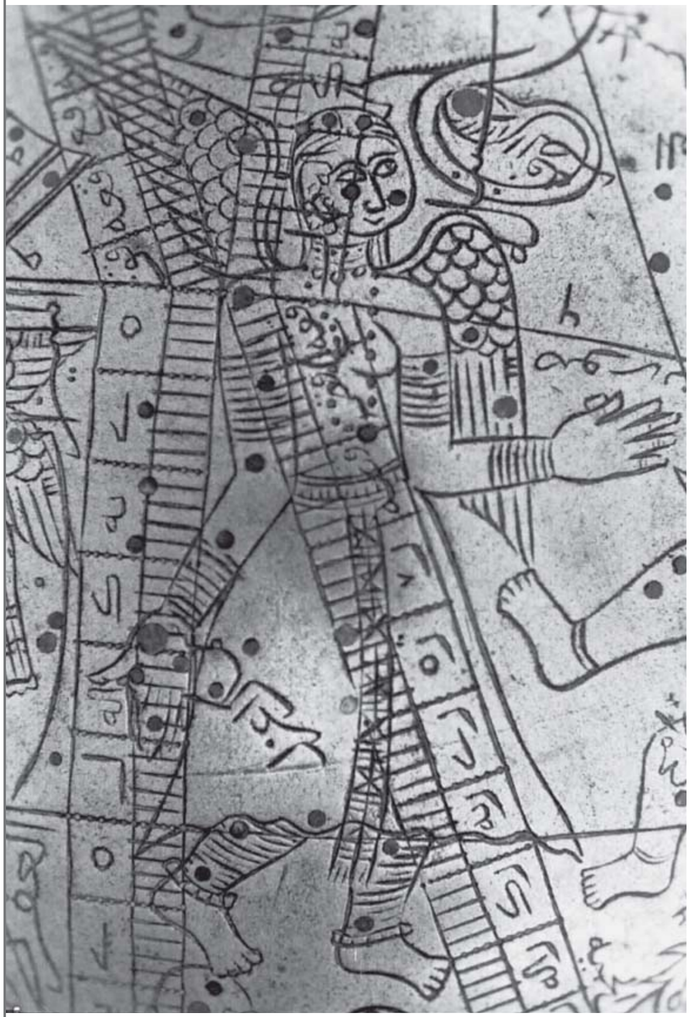

Astronomy, Iconography and Calligraphy

The Constellation Figures on Ziauddin Muhammad's Celestial Globe of 1653-54 CE

Sreeramula Rajeswara Sarma

Astronomy, Iconography and Calligraphy

The Constellation Figures on Ziauddin Muhammad's Celestial Globe of 1653-54 CE

INTRODUCTION

The astrolabe and the celestial globe are the two most important astronomical instruments which were invented in Greek antiquity and which held their sway throughout Europe, the Islamic world and India in the Middle Ages. While the vault of the fixed stars is represented in two dimensions on the astrolabe, it is displayed in three dimensions on the celestial globe. Therefore, the celestial globe is a more convenient tool for teaching and demonstration.

The celestial globe and its companion piece, the terrestrial globe, are said to have been invented respectively by Thales and Anaximander in the sixth century BCE. However, it was Claudius Ptolemy (c. 150 CE) who provided comprehensive and systematic data for the construction and use of both types of globes. On the terrestrial globe, a place is indicated by its geographical latitude and longitude. In his *Geographia,* Ptolemy enumerated the geographical coordinates for about 8000 localities and thus provided the essential data for the construction of the terrestrial globe. Similarly, on the celestial globe, stars are plotted by their celestial latitude and longitude. In his *Almagest,* Ptolemy listed the celestial latitudes and longitudes of some 1022 stars, arranging these stars in forty-eight constellations which include the twelve signs of the zodiac.[1]

Constellations are clusters of stars which were visualized as animal, human, or other forms. The well-known cases are the zodiac signs where, for example, the form of a goat was imagined in a cluster of stars and so was named Aries (in Sanskrit *Mesha*) and the shape of a bull was seen in the next cluster of stars and was designated as Taurus (in Sanskrit *Vrisha*), and so on. Thus the circle of ecliptic, which is the apparent path of the Sun, is made up of twelve different shapes which are known as the zodiac signs. In a like manner, twenty-one constellations were conceived in the hemisphere to the north of the zodiac belt and fifteen in the south. Ptolemy codified these forty-eight constellations and listed the 1022 stars that constituted these constellations.

Since then it has been customary to show the positions of these 1022 stars on celestial globes. The globes also contain the pictorial representations of the forty-eight constellations in their zoomorphic, anthropomorphic and other forms as conceived in Greek mythology, or as modified later in the Islamic world and in India. Interestingly enough, the stars are marked and the constellation outlines are drawn on the celestial globe as seen by an observer from outside the sphere. Therefore, their relative positions are the reverse of those that are actually seen from the earth. Thus the zodiac signs Aries, Taurus and others proceed from the west to the east on the globes whereas they do the opposite when seen from the earth. Moreover, in European globes, the constellation figures are depicted with their faces looking into the globe towards the earth. In Islamic globes, however, these figures face outwards and are thus the exact mirror images of the figures as seen from the earth. This has resulted in the strange situation that the human figures on Islamic globes appear left-handed. Thus, as we shall see below, Perseus severs the head of Medusa with the sword held in his left hand.

In order to determine the positions of these stars, several reference circles are drawn on the globes, such as the celestial equator, the ecliptic, the ecliptic latitude circles and the like. Holes are bored at the two poles of the celestial equator through which an axis runs. The globe is set up on a stand with a horizontal ring and a meridian ring, both graduated in 360 degrees. The axis passing through the two equatorial poles of the globe is affixed to the meridian ring. The globe can be adjusted for the observer's latitude and for the day of observation. Then the portion of the globe seen above the horizontal ring simulates the skies above the observer's horizon on that particular day. One rotation of the globe about its axis shows the apparent motion of the stars above that latitude in the twenty-four hours of that day.

THE CELESTIAL GLOBE IN THE ISLAMIC WORLD

Along with the astrolabe, the celestial globe was transmitted to the Islamic world where it was called *al-Kurah* (the sphere) and several treatises were written and innovations were made in its construction.[2] The most notable Arabic treatise was the *Kitab Suwar al-Kawakib al-Thabitah* (Book of the Constellations of the Fixed Stars), composed by Abd al-Rahman al-Sufi in 974 at Isfahan.[3] Here al-Sufi describes the constellations as seen in the sky by an observer on the earth and again as depicted on the celestial globe. There are extant several exquisitely illustrated manuscripts of this work, showing the constellation figures in both the styles.[4] Al-Sufi also updated Ptolemy's star catalogue. The coordinates of the stars were again updated in the fifteenth century by Ulugh Beg in his astronomical tables. Accordingly, Islamic celestial globes contain the positions of about 1022 stars marked according to the coordinates given by Al-Sufi or by Ulugh Beg and updated to their times.

THE CELESTIAL GLOBE IN INDIA

The astrolabe appears to have been introduced into India by al-Biruni in the early eleventh century. In the late fourteenth century, Firoz Shah Tughlug promoted the production of astrolabes and sponsored the composition of manuals on the astrolabe in Persian and Sanskrit at Delhi.[5] Thereafter, many Indo-Persian and Sanskrit astrolabes were produced in India.[6] The celestial globe, however, was a late-comer; it was mentioned for the first time in connection with Humayun (reign-period 1530-1556), who was interested in astral sciences and instruments.[7]

Humayun's chief astrolabe maker was Allahdad of Lahore. He and his descendants of the next four generations were the main producers of astrolabes and celestial globes in the Mughal period. Some of these instruments were commissioned by high Mughal nobility. Today, there exist in museums and private collections in India, in Europe and in the US, some ninety-five brass astrolabes and about twenty-five brass celestial globes, which bear the signatures of the different members of this family. Besides, there are also dozens of unsigned instruments that can be attributed to this Lahore family for stylistic reasons.[8] Because of the geometrical precision, aesthetically pleasing design and high quality metalwork, these instruments have become prized possessions of collectors and fetch fabulous prices today in the international art market.

It is not known whether Allahdad or his son Isa produced any celestial globes, but there are extant four celestial globes made by Allahdad's grandson Qaim Muhammad between the years 1622 and 1637.

The common practice in the manufacture of globes outside India was to make two hollow hemispheres first and then join them along the seam. But the globes made by Qaim Muhammad were cast as single hollow spheres by *cire perdue* or the lost wax process, which is more time-consuming but artistically more challenging.[9]

ZIAUDDIN MUHAMMAD

The technique of producing seamless celestial globes by the lost wax process reached its pinnacle in the *oeuvre* of Qaim Muhammad's son Ziauddin Muhammad, who was the most prolific and versatile member of this family. He produced over thirty-three astrolabes and seventeen celestial globes between the years 1637 and 1680. Besides the standard astrolabes and celestial globes, he also tried his hand at several rare varieties. For example, he created an unusual celestial globe for no less a patron than Emperor Aurangzeb. After drawing the great circles and the constellation figures on this globe, Ziauddin cut off the remaining metal and marked the stars' positions with holes in the figures. When this perforated globe is held against light, the circles and figures stand out and light shines through the holes representing the stars.[10]

Of the sixteen conventional celestial globes made by Ziauddin, three show just the reference circles and a small number of stars. The rest are highly complex globes, which display approximately 1022 star positions through inlaid silver points and the outlines of the forty-eight constellation figures drawn with consummate skill.

THE ALIGARH GLOBE

Perhaps the finest celestial globe fashioned by Ziauddin Muhammad where astronomy, iconography and calligraphy perfectly match with one another is the small specimen preserved in the library of the Ajmal Khan Tibbia College of the Aligarh Muslim University.[11] This globe has not been studied

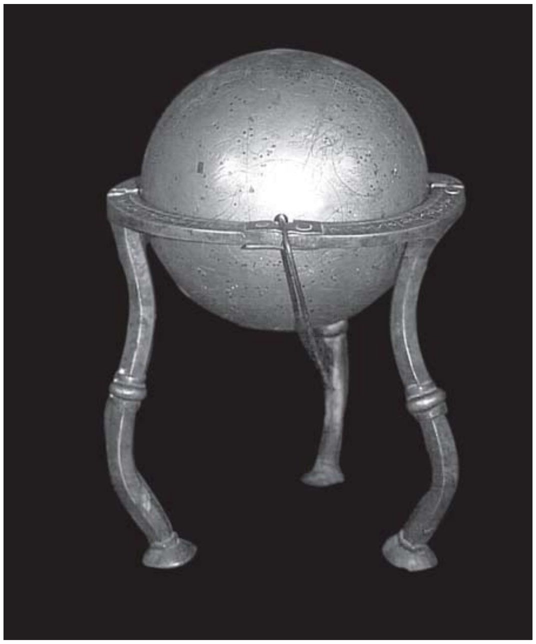

Fig. 19.1. The Celestial Globe made by Ziauddin Muhammad in 1653-54.

in detail so far[12] and is the subject of the present study.

This small globe has a diameter of about 12 cm and rests on a 15 cm high stand. The stand consists of a horizontal ring, which is supported by three legs slightly curved like the Roman letter 'S' (Fig. 19.1). There is a provision for the attachment of the meridian ring and the zenith ring, both vertically, but these two rings are now missing, so also the axis of the globe. The horizontal ring itself was broken and repaired rather crudely. On it is engraved a double band of scales. The inner band is divided into single degrees and the outer band into groups of five degrees. These groups of five degrees are numbered in the alpha-numeric notation called *Abjad* from five to ninety, separately for each quadrant.

The globe itself is in an excellent state of preservation. It was cast as a single hollow sphere by the lost wax process, in the course of which two large holes were cut in the northern and southern hemispheres for removing the inner mould. After that, the holes were filled by matching plugs, and then the complete globe was polished and engraved. A large part of the figure of Perseus is engraved on the plug in the north (Fig. 19.7) and a part of the figure of Centaurus on the plug in the south. Two small holes were bored at the two poles of the equator for the axis to pass through and be pivoted to the meridian ring. This axis is now missing and the globe is held above the frame by means of an iron wire.

The surface area of this small globe is roughly 452 sq. cm, i.e. it corresponds to a sheet of paper measuring 21.26 sq. cm (for comparison, an A4 sheet of paper measures 624 sq. cm). It is remarkable that on this small surface Ziauddin engraved diverse kinds of circular scales, about 1022 star points and 48 outline drawings of men, women, animals, birds, reptiles and inanimate objects, together with their names and the names of more than 100 prominent stars. The names are inscribed in the *Naskhi* style of calligraphy, with different sizes of letters and in different directions to fit in the available spaces and to avoid monotony (Fig. 19.2).

THE CIRCULAR SCALES

On the globe, the two great circles, viz. the celestial equator and the ecliptic, are marked by double bands of scales; one band is graduated in single degrees and the other in groups of five degrees and numbered in the *Abjad* notation. These two scales intersect at an angle of roughly 23, 30 degrees at the vernal equinox and autumnal equinox. The intersections are drawn in an ingenious manner so that there is no overlapping of the lines marking the degree divisions (Fig. 19.2).

The ecliptic is cut perpendicularly by six great circles (drawn as single lines), producing twelve segments of thirty degrees each, to represent the twelve houses of the zodiac. Parallel to the celestial equator are drawn, as

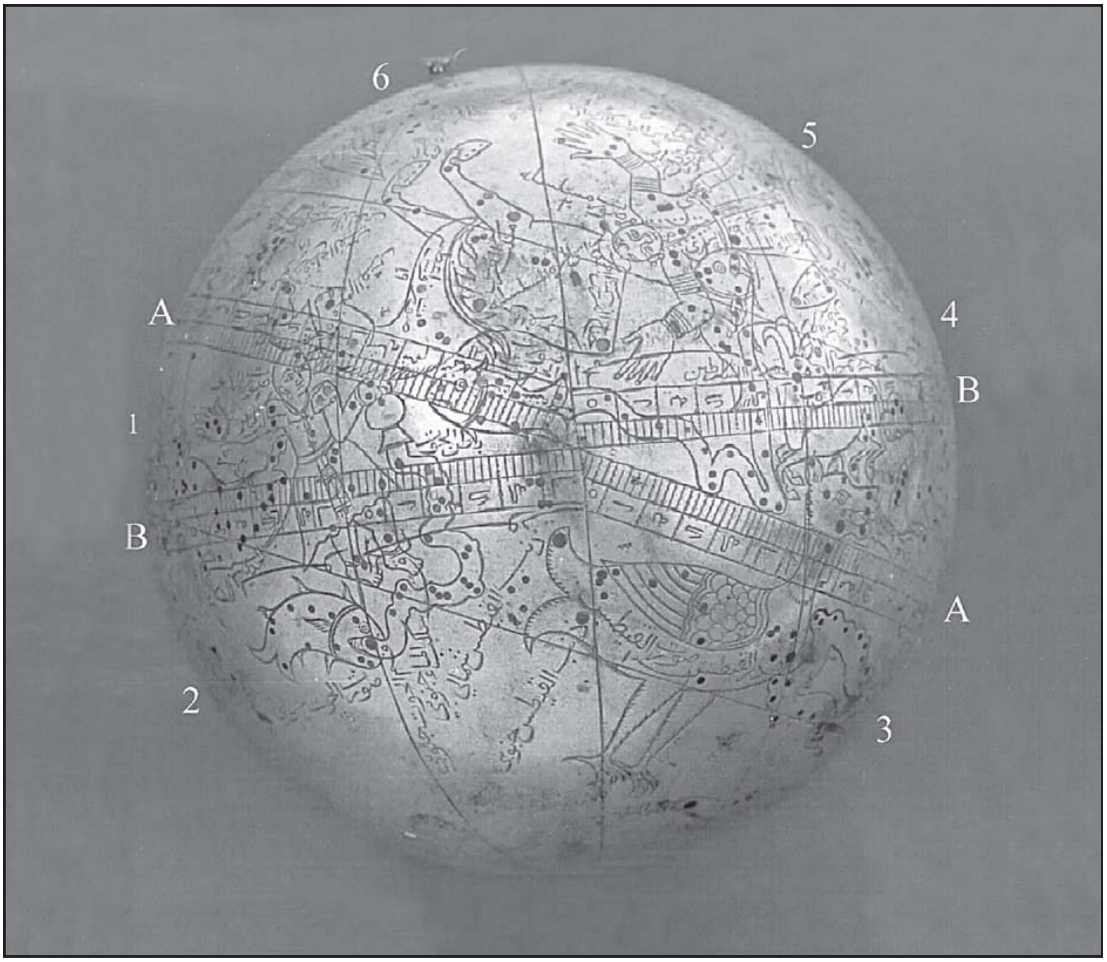

Fig. 19.2. Vernal Equinox and the surroundings. AA Celestial Equator; BB Ecliptic; 1 Aquarius pouring water from a jar; 2 Piscis Austrinus, the southern fish; 3 Cetus; 4 Aries, the horns of which are visible above the Ecliptic; 5 Andromeda with hands outstretched towards the north and south; 6 Pegasus with its forelegs to the north, the neck overlaps the equator band (the horse can be seen better if the image is held upside down).

single lines, the Tropic of Cancer and the Arctic Circle in the north and the Tropic of Capricorn and the Antarctic Circle in the south.

Inside the Antarctic Circle in the south is engraved the globe-maker's signature in Arabic: *amal aqall al-ibad Ziauddin Muhammad ibn Qaim Muhammad ibn Mulla Isa ibn Shaikh Allahdad Asturlabi Humayuni Lahori fi sanah 1064 Hijri*, "The work of the

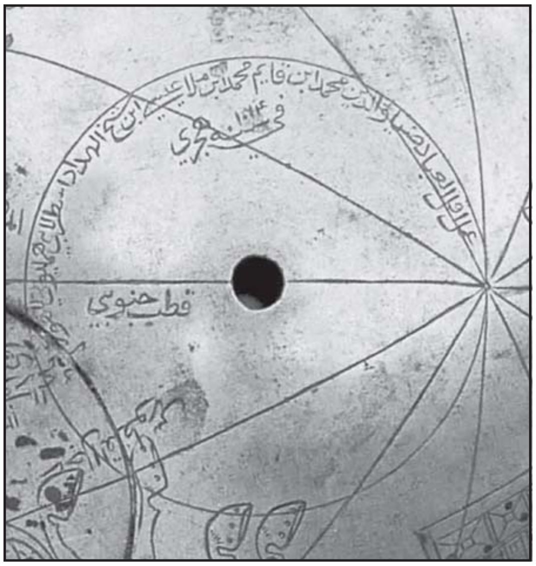

Fig. 19.3. The globe maker's signature; a plug can be seen in the lower left corner.

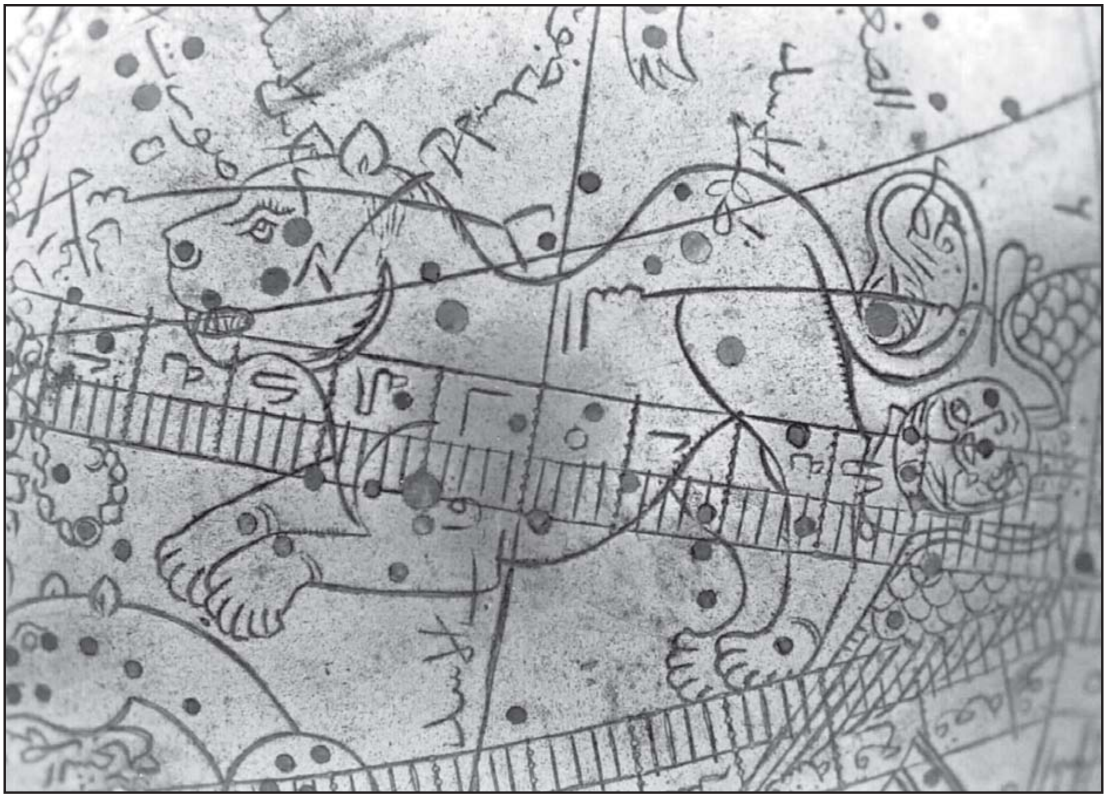

Fig. 19.4. The constellation figure of Leo.

least of the servants [of God], Ziauddin Muhammad, son of Qaim Muhammad, son of Mulla Isa, son of Shaykh Allahdad of Lahore, the astrolabe maker to [Emperor] Humayun, in the year 1064 of Hijra" (Fig. 19.3). The year corresponds to 1653-54 CE.

THE STARS

It has been mentioned above that Ptolemy provided the celestial longitudes and latitudes for 1022 stars. The former is measured along the ecliptic circle from the vernal equinox onwards, and the latter along the latitude circles, to the north or south of the ecliptic. While the celestial latitude remains constant, the celestial longitude varies due to the precesion of the equinoxes and, therefore, has to be updated for one's own time. With the help of these two reference scales, the globe maker marked the positions of about 1022 stars and inlaid these points with silver nails of three different sizes to indicate the different magnitudes (i.e., the degrees of brilliance) of the stars. These inlaid silver points sparkle nicely against the background of the brass globe.

THE CONSTELLATION FIGURES

After inlaying the star points, the outlines of the forty-eight constellation figures were engraved. Actually, the constellation figures do not have much astronomical significance, as they are merely notional figures imagined in the sky for the easy orientation of the relative position of the stars.[13] Even so, the instrument makers took great pains in engraving them. It is here that they display their artistic skill, just as the astrolabe makers show theirs in designing the suspension brackets and the openwork star maps of astrolabes. Ziauddin drew the constellation figures meticulously with very clear lines on

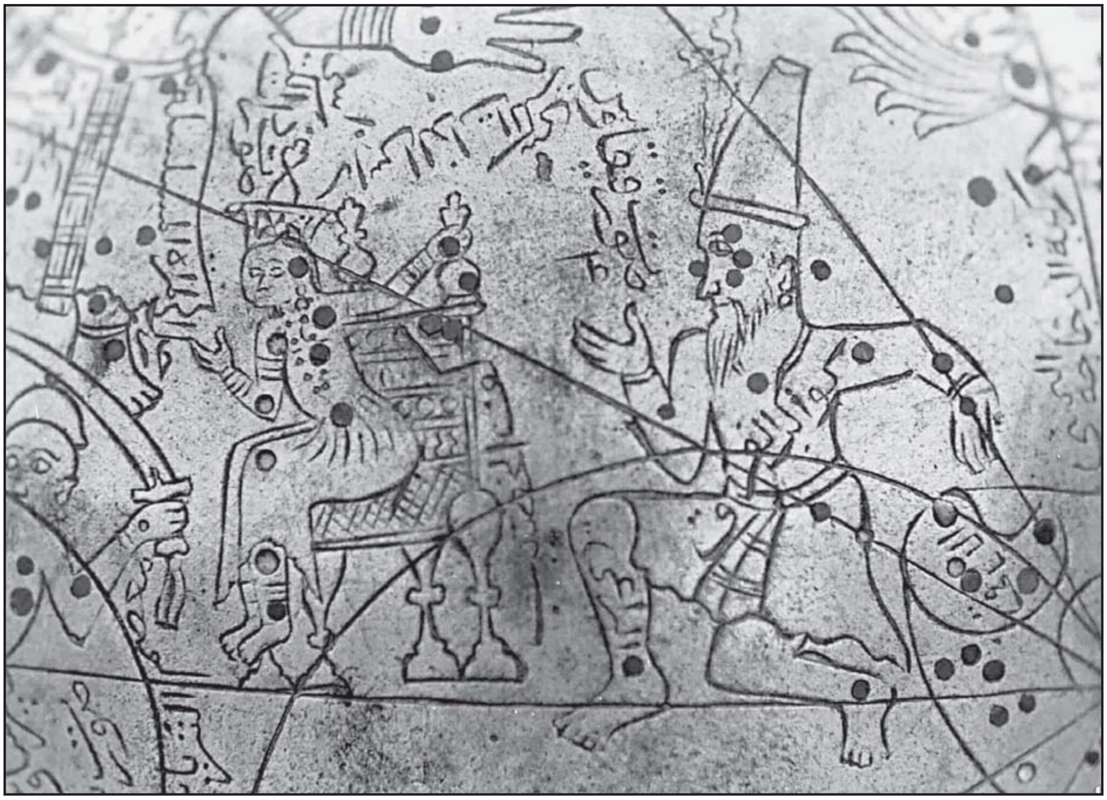

Fig. 19.5. The constellation figures of Cassiopeia and Cepheus.

the Aligarh globe, even though the space available is very small. Each figure drawn here can vie with the figures in the contemporary Mughal miniature paintings.

Of the forty-eight constellation figures, fourteen are anthropomorphic (eleven male and three female), twenty-four are zoomorphic (twelve animals, four birds, eight reptiles) and ten represent various inanimate objects. Let us consider first the figures of the zodiac signs. Though the ecliptic is divided into twelve equal parts and each part of thirty degrees is assigned to a sign, their pictorial representations do not occupy equal spaces. Some figures like Leo and Virgo far exceed the thirty degrees limit, others like Cancer or Pisces are less than thirty degrees. This divergence occurs because the stars constituting the constellations are not placed at regular intervals.

Ziauddin writes the names of the signs just above or below the ecliptic belt, stretching them with long strokes to the extent of thirty degrees. On the constellation figures themselves, he inscribes the names, preceded by the term *surat* (figure, image). This will be clear from the example of the fifth zodiac sign Leo (Fig. 19.4). Unlike the visualization of Leo in the other globes by his father and by himself, here Ziauddin drew the lion very realistically, with the head in profile. The uplifted tail, the snarling teeth and the crouching forelegs suggest that the lion is about to pounce on its prey. The mane is indicated with a few short strokes. The name of the zodiac house, *al-Asad,* is engraved in long strokes across the lion's head. The name of the pictorial representation, *surat al-asad* (figure of Leo), is inscribed above its eye in a vertical line.

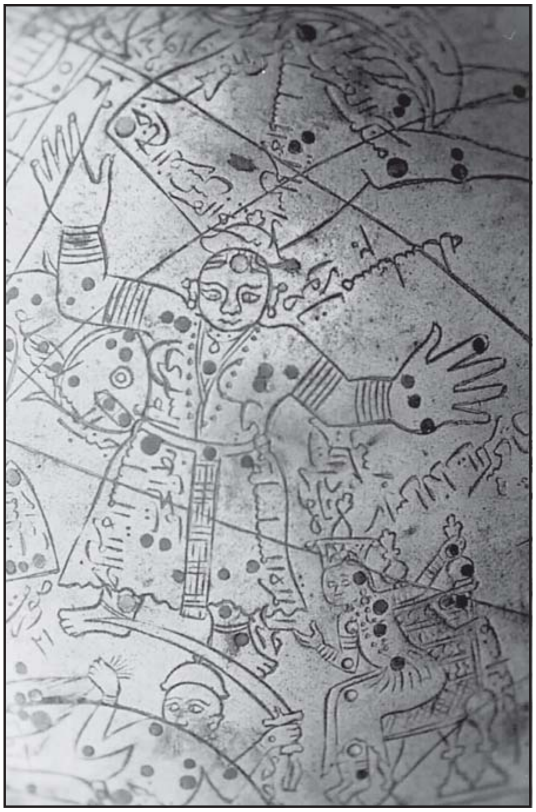

Fig. 19.6. The constellation figure of Andromeda; below her feet can be seen Perseus and on the lower right Cassiopeia.

Some very bright stars are situated on different parts of the lion's body. The names of five of the stars are inscribed. Two are especially worthy of attention. On the tip of the lion's tail is situated a bright star called *al-sarfah* (its modern identification is β Leonis; in Sanskrit *uttara-phalguni*, one of the lunar mansions or *nakshatras*). A very large star on the upper part of the left foreleg is *qalb al-asad* (the heart of the lion, α Leonis, commonly known as Regulus; in Sanskrit, it is *magha*, a lunar mansion). These two are very bright stars and their higher magnitude is indicated by larger silver points.

THE ANTHROPOMORPHIC FIGURES

Of special interest are the anthropomorphic figures that are derived from Greek mythology. In their transit from the Greek and Roman antiquity to India through the Islamic world, their mythological significance was often lost and their nomenclature and iconography went through many regional transformations.

The greatest transformation is in the clothing of men and women, which reflects contemporary styles as seen in Mughal miniature paintings. On this globe, men wear short *jamas* that reach below the knees, while women's *jamas* are longer and reach to their ankles. In both cases, the *jama* is closed in the front up to the sash or the waist band; below the waist the *jama* spreads out to both sides.[14] The sash is simple without any loop, shown by just two parallel lines. Usually only one end of the sash is drawn; it reaches up to the hemline and is richly patterned. Under the *jama*, both men and women wear *shalwar* that tightly hugs the legs below the knees. The ends of the *payjama* legs are shown by two lines on the ankles. Likewise, the sleeves of the *jamas* are indicated by two lines on the wrists.

Women are adorned with bead necklaces and rows of bangles on wrists and upper arms. Both men and women wear caps of diverse types. Interestingly enough, men and women are drawn with two earrings on each ear. But all persons on this globe are barefoot, although Ziauddin draws shoes in some of his other globes.

The importance of this celestial globe lies in the fact that, even though all the three women, viz. Cassiopeia, Andromeda and Virgo, wear nearly the same kind of clothing and jewellery, they are highly individualized in their facial features and gestures.

MUGHAL RENDITION OF A GREEK MYTH

It is not possible to describe all the constellation figures in this limited space. We will concentrate on just a few that jointly enact a poignant drama in the high skies. According to Greek mythology, Cassiopeia, wife of Cepheus, king of Ethiopia, boasted that she and her daughter were fairer than the Nereids. As punishment for this presumption, Poseidon sent the sea monster Cetus to ravage Ethiopia. The only way to pacify Poseidon was to sacrifice Andromeda, the daughter of Cepheus and Cassiopeia, to Cetus. Therefore, Andromeda was chained to rocks on the sea coast and left to the mercy of the sea monster. She was rescued by Perseus who, mounted on the flying horse Pegasus, slew Medusa and turned Cetus into stone by showing to it the head of Medusa. Anybody who looked at Medusa directly became a stone; Perseus avoided looking at her directly. He slew her by looking at her reflection in his polished shield.

All these men, women and beasts were elevated in Greek mythology to the stellar heavens; consequently, their figures occupy a large part of the celestial globe. These constellation figures reached the Islamic world, however, without their nomenclature and without the myth that connects them. In the case of Cassiopeia, her chair appeared to be a prominent feature and therefore she was designated as *Dhat al-Kursi* (the one with the chair). Her daughter Andromeda's chains looked striking, and so she was named *al-Marah al-Musalsalah* (the chained woman) or simply *al-Musalsalah* (the chained one); even so, she was often depicted without any chains, as in the present globe. The names of the two men were merely transliterated: Cepheus as *Qiqaqus* and Perseus as *Barsaus* (or *Parsaus* in our globe). In the Greek myth, Perseus carries in one hand the severed head of Medusa, who has snakes on her head instead of hair. These snakes were transformed into hair on Islamic globes, and the streams of blood issuing from her severed head became a beard. This bearded person received also a new name *al-ghul,* an Arabic expression that gifted the word 'ghoul' to the English language.

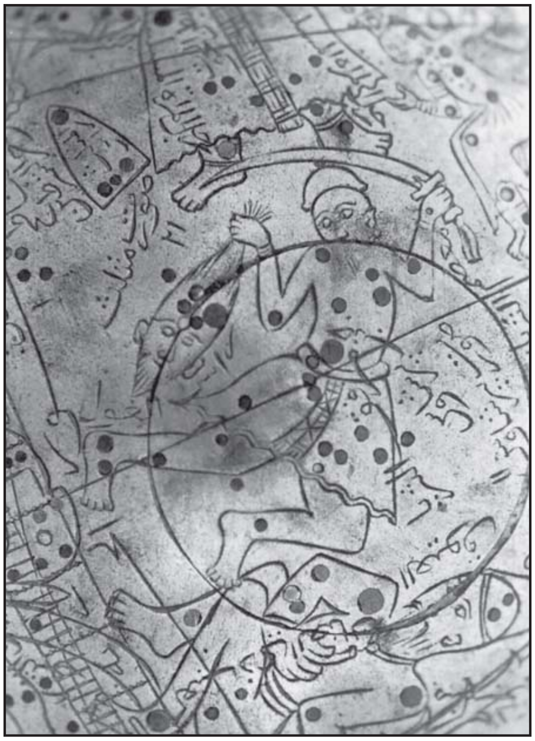

Fig. 19.7. The constellation figure of Perseus; notice the circular plug that covers almost the entire body of Perseus.

On the present globe, Cassiopeia is depicted as a slender woman seated on the edge of a high and richly carved chair. Her face is slightly turned towards the left so that her face is in half profile. With her left hand she is holding the left back post of her chair, and pointing the right hand to Andromeda. Cassiopeia wears a large crown, which is decorated on the top with an hour-glass shaped ornament; similar ornaments are also on the tops of the two back posts of the chair. Her long *jama* reaches almost up to her ankles; below the hemline can be seen the tight *shalwar.* A bead necklace is around her neck and rows of bangles adorn her wrists and upper arms (Fig. 19.5).

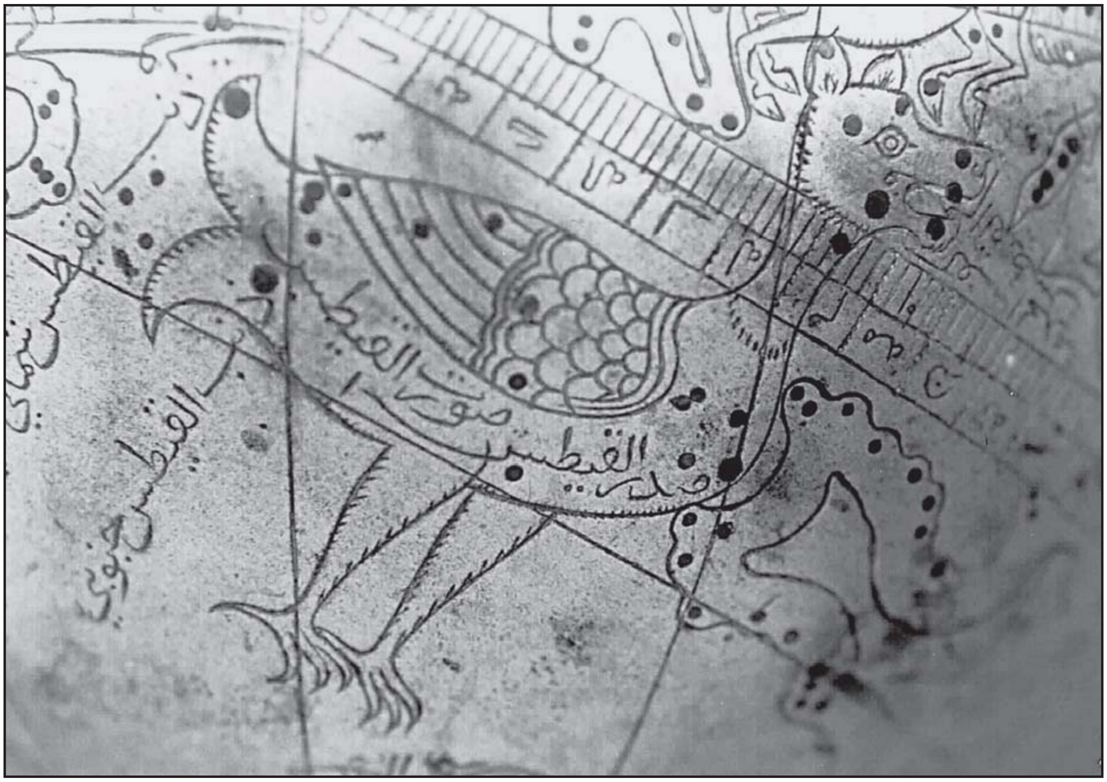

Fig. 19.8. The constellation figure of Cetus.

Cassiopeia's husband Cepheus is drawn in profile with a beard and a high conical hat with a plume (Fig. 19.5). He is clothed in a knee-length *jama*. The patterned end of the sash reaches up to the hem of his *jama*. Double earrings can be seen on his left ear. Above his right hand is engraved the label *surat qiqaus* (figure of Cepheus). On his upper left arm is a star; its name *kawkaba al-firq* ($\alpha\beta$ Cephei) is engraved in large letters across the *jama* like a decoration. Likewise, the name of the star on his right ankle *al-rami* (short for *simak al-rami,* α Bootes), engraved on his calf, suggests the folds of the leg covering, but his left leg is bare.

Their daughter Andromeda is a striking figure. She is shown in front view, a full-breasted plump young woman, with her arms spread wide (Fig. 19.6). She is dressed in an ankle-length *jama*. A sash goes around her waist and its patterned end reaches up to the hem of the *jama*. The names of stars written vertically on the left and right edges of the flared *jama* look like decorative patterns. Here the calligraphy is particularly well integrated with the clothing. She wears a series of bangles on her upper arms and wrists, a bead necklace around her neck and two rings each on both her ears, and a somewhat flat cap with a pompom on the top.

Andromeda's rescuer Perseus also wears such a cap. He is also shown in front view, with a thin beard. His *jama* is rather short and does not reach up to the knees; by design or by mistake, his *shalwar* is not indicated. As mentioned above, due to the left right reversal on Islamic globes, Perseus holds the sword in his left hand and the severed head of the victim in his right (Fig. 19.7).

Ziauddin drew these figures with vivid expressive postures. Even though he was not aware of the Greek mythological background of these characters, he endowed them with appropriate facial expressions. Cepheus, bending his knees and raising his right arm from behind Cassiopeia's chair, seems to be remonstrating with his wife. There is movement even in the sitting Cassiopeia who looks as if she wishes to get away from the husband's entreaties and reach out to Andromeda. Andromeda, left on the rocks to the mercy of the sea monster, is stretching out her arms imploringly, stark horror writ large on her face. There is a three-dimensional effect in her large palms; it looks as if she is stretching out her hands towards the observer, beseeching him to rescue her. The posture of Perseus suggests that he is rushing to Andromeda's rescue.

Of the beasts in the myth, Pegasus (in Arabic merely *faras azam*, 'the larger horse'), the winged horse that carried Perseus, is not shown in full on celestial globes, but only the forepart consisting of the head, the neck with long mane, wings, and the two forelegs: the hind part is reduced to a rectangular stump. Ziauddin's equine figures are always well drawn, although the head of Pegasus is somewhat obscured by the overlapping band of the celestial equator (Fig. 19.2).

The other beast, the sea monster Cetus (transliterated as *qitus*), is drawn in full and in great detail. While the Greeks imagined the constellation as a huge whale, on Islamic celestial globes it has a weird composite form: a snarling dog's head with a collar around the neck, bird's feet, and a feathered fishtail (Fig. 19.8).

THE CONSTELLATION FIGURE OF VIRGO

Ziauddin's most accomplished constellation figure on the present globe is that of Virgo. In no other globe did Ziauddin lavish so much detail on Virgo and infuse the figure with an individual personality as he did here (Fig. 19.9). Virgo is depicted as an elegant Mughal princess, walking with a graceful step, perhaps on her way to a rendezvous with a lover. She is drawn in front view, with her face slightly turned to the left. She has a round face, finely arched eyebrows, almond-shaped eyes and a smiling mouth. Her hair is parted in the middle and hangs down on the back; some strands are visible on both sides of her slender neck. The breasts are clearly outlined.

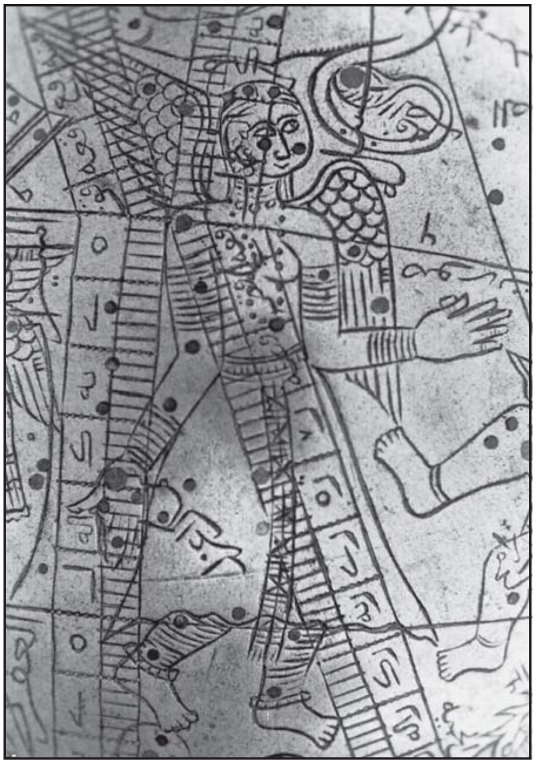

Fig. 19.9. The constellation figure of Virgo.

She wears an ankle-length *jama* with a very wide skirt below the waist. There is a sash around her waist, one end of which extends beyond the hemline of the *jama*. Below the hemline of the *jama*, the folds of the *shalwar* are carefully drawn. The celestial equator with its degree divisions and numbers overlaps her entire body, but it does not obscure her figure. On the contrary, it looks like a decorative feature of her *jama*. Likewise, the two star pointers on her cheeks look more like beauty marks rather than stars. Besides rows of bangles on her wrists and on her upper arms, she also has anklets. Around her neck, there is a choker fringed with pearls, besides a long necklace that reaches up to her waist. Her wings are drawn with great detail of feathers.

In drawing her wings, arms and legs, Ziauddin avoids symmetry. Their asymmetric arrangement suggests movement and adds charm to the figure. Both upper arms are held close to the body, but her left lower arm is raised perpendicular to the body. Her right lower arm is slightly raised. It looks as if she is holding a large silver disk in her right palm, to carry it to the lover as a luminous gift. This large silver point actually represents the star *simak azal* (α Virginis, commonly known as Spica; Sanskrit *chitra,* a lunar mansion), which is the fifteenth most brilliant star in the heavens.

NOTES AND REFERENCES

1. Ptolemy's *Almagest,* translated and annotated by G.J. Toomer, Springer-Verlag, New York, 1984, pp. 341-99.
2. Emilie Savage-Smith, *Islamicate Celestial Globes: Their History, Construction, and Use*, Smithsonian Institution Press, Washington D.C., 1985, contains an excellent study of the celestial globe in the Islamic world with a detailed catalogue of 132 extant specimens.
3. M. Nizam'd-Din (ed.), Abu'l-Husain 'Abdu'r-Rahman as-Sufi, *Suwaru'l-Kawakib,* Osmania Oriental Publications Bureau, Hyderabad, 1954.
4. See, e.g., Emmy Wellesz, *An Islamic Book of Constellations*, Bodleian Library, Oxford, 1965.
5. On the early history of the astrolabe in India, see Sreeramula Rajeswara Sarma, 'Sultan, Suri and the Astrolabe', *Indian Journal of History of Science*, 35, 2000, pp. 129-47.
6. On Sanskrit astrolabes, see Sreeramula Rajeswara Sarma, 'Yantraraja: The Astrolabe in Sanskrit', *Indian Journal of History of Science,* 34, 1999, pp. 145-58.
7. Sreeramula Rajeswara Sarma, 'From al-Kura to Bhagola: On the Dissemination of the Celestial Globe in India', *Studies in History of Medicine and Science*, 13.1, 1994, pp. 69-85.
8. Sreeramula Rajeswara Sarma, 'The Lahore Family of Astrolabists and Their Ouvrage', *Studies in History of Medicine and Science,* 13.2, 1994, pp. 205-24.
9. On casting celestial globes by the *cire perdue* method, see Savage-Smith, op. cit., pp. 91-95.
10. Ibid., pp. 232-33, Figure 17.
11. I am grateful to the authorities of the Tibbia College for allowing me to study and photograph the globe.
12. A brief description appeared in: Sreeramula Rajeswara Sarma, 'From al-Kura to Bhagola', op. cit.
13. Of course, the twelve zodiac signs enjoy great importance in astrology.
14. In the *Ain-i-Akbari,* these are called *peshwaz*; see *The Ain-i-Akbari of Abul Fazl Allami,* tr. H. Blochmann, Vol. I, p. 89: "The *Peshwaz* (a coat open in front) is of the same form, but ties in front." For a sketch of this type of *jama* as depicted in Mughal miniatures, see Som Prakash Verma, *Art and Material Culture in the Paintings of Akbar's Court,* Vikas Publishing House, New Delhi, 1978, Plate XXX.1.

The articles mentioned in notes 5, 6, 7, 8 and 12 are reprinted in: Sreeramula Rajeswara Sarma, *The Archaic and the Exotic: Studies in the History of Indian Astronomical Instruments,* Manohar, New Delhi, 2008.